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STATE ENGINEERING EXPERIMENT STATION

The Research Engineer

GEORGIA SCHOOL OF TECHNOLOGY

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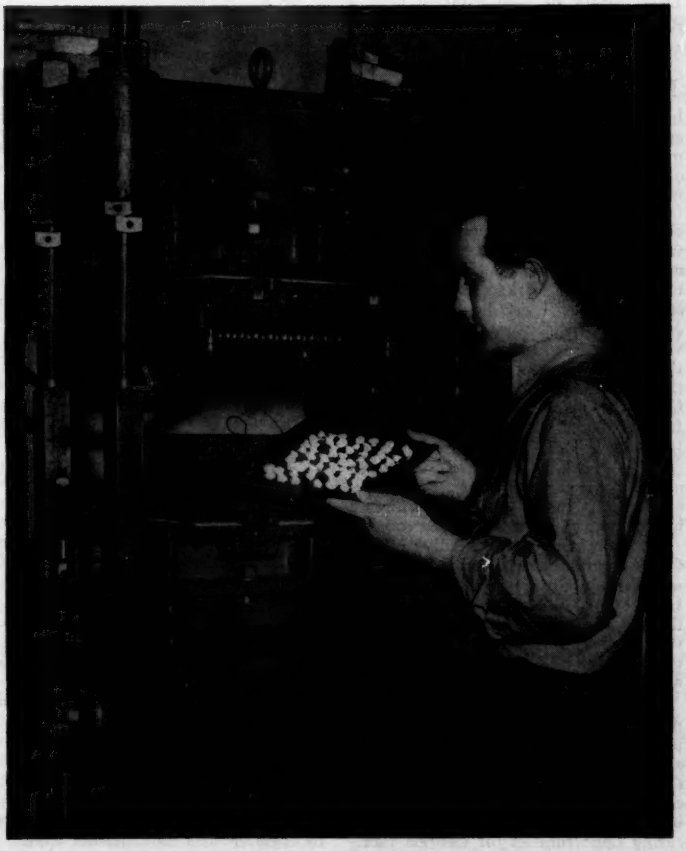

The Research Engineer

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GERALD A. ROSSELOT, *Director* — B. H. WEIL, *Editor*
PAUL WEBER, *Assistant Director* — MARJORIE BOLEN, *Assistant*

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PLASTICS AND GEORGIA

In connection with their present accelerated programs of industrial development, many Georgia industrialists have often posed the question: "What about manufacturing plastic articles here in Georgia"? This same query has also been heard from veterans and others who desire to establish themselves in manufacturing operations and who need to know about markets and the technical and financial details of operations. Joining in this chorus are those who are vitally interested in the increased use of the material resources of the state and the establishment of new industries in Georgia; who wonder about the manufacture of plastics as a potential industry to help accomplish both purposes.

The problem, of course, is by no means restricted to Georgia aspects. Certain manufacturers within the state are using plastics which cannot be produced (chemically or economically) from Georgia products and which cannot be replaced by Georgia-produced plastics. In this case, no opportunity exists for the use of Georgia raw materials, but there may be a possibility of fabricating the plastic parts employed if enough are needed.

On the other hand, certain other plastics needed in the Southeast may be producible from Georgia materials, or entirely new plastics may be found through research and then developed commercially. New plastic articles may be designed which will create manufacturing opportunities for Georgia fabricators. Surveys of national markets may indicate the profitability of manufacturing an article or plastic in Georgia for wide distribution, balancing labor supply and power availability against the possibility that some other location may be closer to markets or raw materials.

All of these factors, of course, depend upon specific conditions for their determination, and these, in turn, ultimately depend upon plastic materials and their fabrication methods. While much has been published on these subjects, little material has ever been directly related to Georgia and the Southeast, and many questions regarding plastics and this area have been directed to the Station for answer.

The symposium on plastics contained in this issue was prepared, therefore, in an attempt to outline the plastics picture in regard to materials and fabrication and their relationship to the Georgia scene. For obvious reasons, no attempt has been made to present an exhaustive account, but every effort has been made to give a basic description of the factors involved.

Georgia will probably never become a leading producer of plastics, plywood aside, and its future as a fabricator will depend upon its continued industrial growth. Both phases of the plastics industry depend heavily upon scientific and technical research for their vitality, however, and for this reason the many aspects of the industry are of interest to engineers and industrialists alike.

PLASTIC MATERIALS

By B. H. WEIL*

The manufacture of plastics and their fabrication into articles of commerce are of increasing importance to industry as a whole. This article, the first of three devoted to phases of this subject, constitutes a brief survey of the plastic materials and a discussion of the basic chemistry and raw materials involved.

According to popular belief, plastics and other "miracles of modern chemistry" are substances which the chemist prepares by mixing "coal, water, and air" in some mysterious manner. In actuality, as chemists and engineers know only too well, the manufacture of commercial plastic materials is an operation involving one or more typical "unit organic processes," carried on in equipment designed in accordance with chemical engineering "unit operations."

As regards raw materials, it is perfectly true that the majority of the chemicals used in the synthesis of plastics are derived from coal, petroleum, and agricultural materials, often by reactions which use (among other substances) water and air, but the actual synthesis steps are concerned with the chemicals themselves and not with their basic materials. In the synthesis of the alkyd resins, it matters not at all whether the phthalic anhydride used was produced from coal-tar naphthalene or petroleum ortho-xylene.

DEFINITIONS

Plastics, according to definition, are materials which can be given a definite form by the application of heat or pressure, or both, and which retain their new form after the stress or heat is removed. In a loose sense, such materials as putty, clay, glass, and metals are plastics, but industry generally applies this term to substances which can be fabricated under moderate temperatures and pressures, yet do not melt or soften under ordinary conditions. Even more specifically, the term "plastics" is used to describe the limited number of natural, synthetic, and semi-synthetic organic chemical materials which possess the above properties.

A "resin," in turn, is a semi-solid or solid complex mixture of organic compounds, with no definite melting point and characterized by a typical luster and fracture. "Resin" and "plastic" are often misused interchangeably; while most resins may be made into plastics, there are many plastics which do not have the properties of resins.

To confuse the issue still further, reference is often made to plastic paints, plastic adhesives, and similar materials which certainly do not meet the above description. What is really meant, of course, is that the same chemical materials which may be molded into solid articles may also be used to form the body of paints or to serve as an adhesive, as the case may be. In actuality, also, many plastics differ only slightly, if at all, from synthetic fibers and synthetic rubbers. For example, certain polyvinyl resins may be drawn and spun as synthetic fibers ("Vinyon"), molded as plastics ("Vinylite," etc.), or plasticized and used as a synthetic rubber ("Koroseal," etc.).

BASIC CHEMISTRY

No detailed discussion of plastics chemistry is in order here, but it may be noted that all plastics are made up of macromolecules, formed (naturally or synthetically) by joining many smaller groups of atoms (called *monomers*) into long chains (sometimes tied together by cross-linkages) called *polymers*. Polymer formation may be effected by either of two processes—polymerization or condensation.

In *polymerization*, small "unsaturated" molecules (molecules whose carbon atoms are not bound to the maximum number of other atoms) add to each other to form long polymers without the loss of any constituent; "copolymers" may be formed by the reaction of two different unsaturated monomers.

The formation of giant molecules by *condensation* occurs when monomers containing different types of reactive groups interact to form a compound which still pos-

*Research Associate Professor; Chief, Technical Information Division, State Engineering Experiment Station.

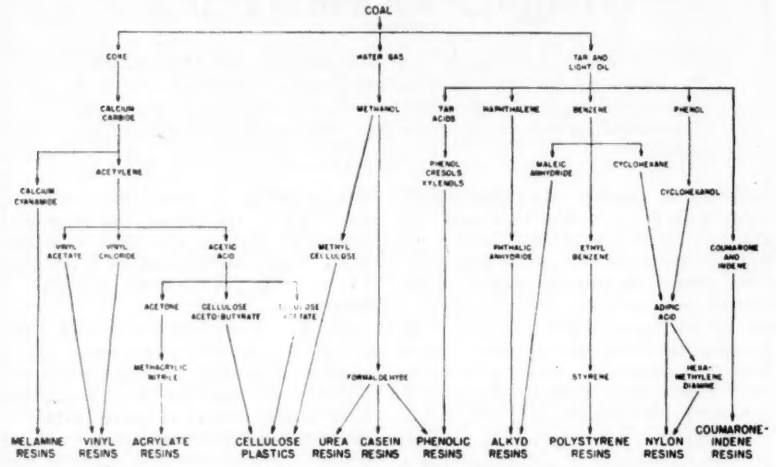

Figure 1. Plastics from coal.

sesses reactive groups, and which therefore is able to continue to expand in size through further reaction. Condensation differs from polymerization in that a simple molecule, such as H_2O, is eliminated by the reaction in each step.

CLASSIFICATION

In regard to their practical usage, plastics are divided into two general classes in accordance with their behavior when exposed to heat. Those which are *thermoplastic* become soft upon heating above a certain point (sometimes under pressure), harden when cooled, and then soften again if reheated, the cycle being capable of infinite repetition. *Thermosetting* plastics, on the other hand, while being soft enough to mold when heated for the first time, are permanently hardened by the heat and cannot be remelted for remolding.

A rather good correlation appears to exist between these class terms and the processes of polymerization and condensation. Thermoplastics are believed to be plastic because their long molecular chains are formed by polymerization and are not rigidly bound together. Thermosetting compounds are plastic only until cross-linkage between chain segments occurs, as in the final stages of condensation reactions; after this, they are permanently rigid in regard to heat (up to the point of decomposition).

KINDS OF PLASTICS

No single article can present a detailed description of the many plastics available today. A few of these, such as the nitrocellulose plastic *Celluloid* and the phenolic plastic *Bakelite*, have long been familiar to the public, but only scientists, the plastic materials industry, and the processors of plastics are fully aware of the fact that literally hundreds of chemically different plastics are now in use and that many more are known or are being discovered.

Figures 1 and 2 give some idea of the complexity of the situation and make possible, at the same time, the interesting and economically important observation that many of the plastics can be produced from either "coal" or "petroleum" intermediates. Agricultural materials are not shown, but it may be noted that many of the plastics listed here require cellulose as a basic raw material, while certain of the alkyd resins are prepared from rosin esters.

Phenolic Plastics

Most widely used of all the molding materials, the phenolic plastics are also used in adhesives, paints, varnishes, abrasives, cast-

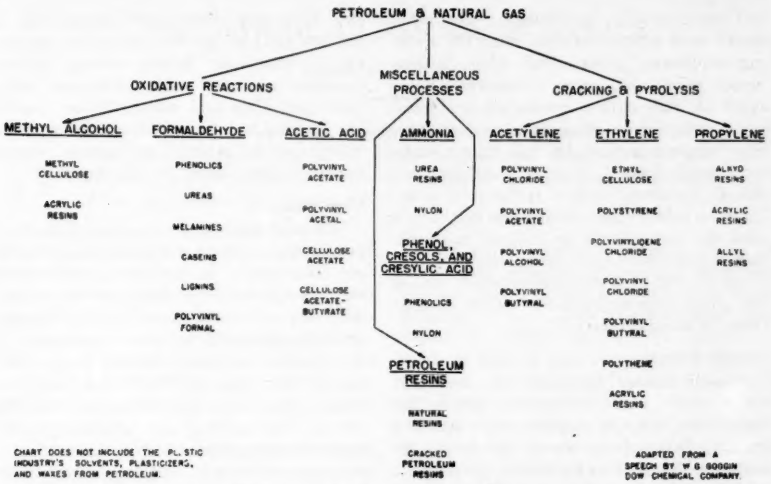

Figure 2. Plastics from petroleum.

ings, and laminates, being available in the form of sheets, rods, tubes, and liquids. Phenol and formaldehyde, the chief chemical intermediates, are now generally obtained from coal derivatives but may both be produced from petroleum; cresols and cresylic acids from both sources are often substituted for phenol, while furfural (from agricultural wastes) and other aldehydes yield valuable "phenolics" when substituted for formaldehyde. Wood flour is the most widely used "filler"; shock resistance is imparted by the use of cotton, shredded cloth, or paper pulp; powdered mica gives low dielectric loss.

Cellulose Plastics

Cellulose derivatives have been finding wide and increasing applications. *Cellulose nitrate*, the grandfather of the plastics industry, is still very important as a lacquer base for protective coatings, as raw material for artificial leather, and as a molding material for a host of novelty uses which range from brushes to piano keys. Among the cellulose ester plastics, *cellulose acetate* is still most important, being produced in sheets, rods, and tubes for fabrication by injection molding and extrusion into a host of molded products. *Cellulose acetate-propionate*, *cellulose acetate-butyrate*, and *cellulose propionate* are other plastics produced by reacting cotton linters or purified wood pulp with organic acids from coal or petroleum derivatives; special properties such as increased moisture resistance and greater stability compensate for their increased price. Scintillating fibers are also made from cellulose acetate-butyrate.

The cellulose ethers include *methyl cellulose* and *ethyl cellulose*, produced by reacting cellulosic materials with methyl chloride or ethyl chloride, respectively, in the presence of an alkali. The latter is used in many molded products (ice trays, electrical appliances, etc.), being tough, impact resistant, dimensionally stable, water resistant, etc.; it is also of great importance in the formulation of important new lacquers and as a "strip-coat" base. Methyl cellulose is an excellent paper size and textile treating agent.

Vinyl Resins

In by far the greatest demand among the newer resins are the vinyl materials, produced by various reactions from acetylene or ethylene and dependent for their polymerization ability upon the chemical structure of the latter. *Polyvinyl chloride* has been used in wire insulation, gaskets, protective coatings, shower curtains, waterproofed fabrics,

and countless other applications. *Polyvinyl acetate* is an adhesive of great merit for bonding cellophane, paper, cloth, glass, leather, wood, metal, and other substances. *Polyvinyl chloride-acetate* copolymers are versatile plastics for use in noiseless records, shoe tips, suspenders, can linings, pump gears, etc.; textile fibers ("Vinyon") are also produced. *Polyvinyl butyral* is the chief interlayer for safety glass; during the war, it was used for such articles as military raincoats. Other important vinyl resins include *polyvinyl alcohol* and *polyvinyl formal;* use of this entire class of plastics is certain to continue to increase rapidly.

Acrylic Resins

Closely related chemically to the vinyl resins are the acrylic resins, most famous for their wide usage in airplane nosepieces and turrets. Being thermoplastic (as are all the materials discussed so far except the phenolic plastics), they may be molded by compression or injection. Applications include artificial dentures, adhesives, impregnating materials, textile finishing agents, optical lenses, and such novelty and utility items as dresser sets, transparent tables, pipe stems, and salad sets.

Styrene Resins

In great demand before the war, and now being produced in quantities over 20 times as great as then because of the availability of styrene from war-built synthetic rubber material plants, the *polystyrene* resins yield many beautiful and useful products. High chemical resistance is of importance in battery boxes, bottle caps, and dishes; low temperature strength and moisture resistance cause wide usage in refrigerators; excellent electrical properties are the basis for considerable use in radio and television parts.

In addition to its utility applications, polystyrene is finding much use on the basis of its crystal clarity and ability to take lovely tints.

Other Thermoplastics

Many other thermoplastic materials are finding wide usage. *Saran,* a vinylidene chloride polymer derived from petroleum chemicals, is finding extensive applications in extruded tubing and pipes and, in fiber form, in house screening, seat covers, fishing lines, etc. *Polythene,* introduced domestically in the late years of the war, is finding application in containers, flexible tubing, gaskets, coatings, wire and cable insulation, adhesives, and films and sheets. *Nylon* plastics are important where heat resistance is involved; such plastics are almost unique among thermoplastics in this respect.

Urea Resins

Derived basically from ammonia and carbon dioxide (which yield urea) and hydrogen and carbon monoxide (generally used for formaldehyde production, via methanol), the urea resins have long been important thermoplastic materials, especially for compression molding. Purified wood cellulose is the common filler. Available in a broad color range, the urea resins are widely used in the molding and laminating fields; typical uses include adhesives, baking enamels, scale housings, radio cabinets, tableware, electrical switches, knobs, light shades and reflectors, and impregnating agents for wet-strength paper. *Melamine* resins are closely related in composition and characteristics, and greater moisture resistance and surface hardness offset higher costs in many applications.

Alkyd Resins

These resins are the products of reactions between polybasic organic acids (phthalic acid, maleic acid, abietic acid (purified rosin), adipic acid, etc.) and polyhydric alcohols such as glycerine and glycol, often modified further by fatty acids and oils. Such resins have attained great importance in paints because of an unusual combination of durability, drying power, color retention, and excellent adhesion. Sealers and lacquers of the furniture industry are made from blends of the rosin-modified maleic alkyds with nitrocellulose; other uses of the alkyds include application in printing inks and artificial leather, although passenger car finishes and house and marine paints take the bulk of production.

Other Industrial Plastics

Long known, and produced from skimmed-milk casein which has been hardened by immersion in formaldehyde, the *casein*

Continued on Page 17

THE FABRICATION OF PLASTICS

By H. V. GRUBB*

The production of "molded" plastic articles requires equipment designed for the selected purpose and suited to the plastics used. The following article presents a description of the basic techniques and equipment currently used in the forming of plastic products.

Plastics, today, are substances which have wide utility and appeal. The public has grown almost accustomed to hearing about new plastics for use in unusual applications. Technical debates about "plastic automobiles" and the like have long since become material for popular discussion. The average individual is pleasantly certain that plastics are here to stay.

Despite this awareness of plastic materials and articles, however, few persons, technically trained or otherwise, know much about the methods and equipment by which plastic raw materials are formed into final shapes. This lack of information may, at first glance, seem unimportant, but this is far from the case.

If plastics are to be used properly, their fabrication must be effected in equipment which is best suited to the purpose and the specific plastic required, equipment which is also chosen on the basis of economics. Such selection, ultimately, should be the decision of the manufacturer, but it should be remembered that many plastic articles are the design of companies which want them for specific purposes (use or sale) and that the plastics fabricator is often not consulted until plans, often based on a specific plastic, are relatively complete. For this reason, awareness of the existence of possible complications, economic and technical, might prove of service.

Furthermore, many veterans and others are considering entry into the field of plastics fabrication, yet are lost in a maze of information about specific equipment and processes.

It is to clarify some of the confusion on this subject—the fabrication of plastics—that this article has been prepared. While several of the plastic materials have been known for a number of decades, many of the present methods of plastics fabrication are less than 15 years old; therefore, a description of techniques and equipment may prove of general interest. No attempt is made to describe plastic coatings, an important use, but attention instead is concentrated on the preparation of "solid" articles.

The fabrication of plastics may include practically all of the methods used in the fabrication of most of the other structural materials. For example, plastics are blown in making bottles in much the same manner that glass is blown; they may be drawn in presses similarly to metals; they may be cut and machined to shape, much as wood and metal; and they are even cast to shape in the same manner as metals. The more important methods of fabrication, however, are compression molding, injection molding, extrusion, and laminating, either high or low pressure.

COMPRESSION MOLDING

Compression molding is the method of fabrication primarily applied to the thermosetting plastic materials. The thermosetting materials are those compounds which set or cure upon the application of heat and pressure in much the same manner that concrete cures; consequently, they cannot be reworked. Many of these materials are among the cheapest of the plastics, however, and

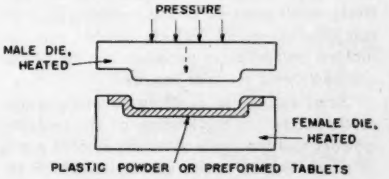

Figure 1. Compression molding.

*Associate Professor of Chemical Engineering.

have perhaps their widest application in industrial and commercial uses, although large amounts are also used in toys and novelties, decorative applications, and other nonfunctional uses. The thermosetting resins possess, in general, greater hardness, better chemical resistance, and higher heat resistance than the thermoplastic materials, which will be discussed later.

In compression molding, the molding compound, which consists of the resin, filler plasticizer, lubricant, and dyes or pigments, is loaded in powder form into heated molds. These are then closed with a force great enough to provide a pressure on the material of between 2,000 and 5,000 pounds per square inch of projected area of the molded piece or pieces, depending on the depth of the part, the thickness of the sections involved, and the intricacy of the piece. Upon the application of heat and pressure, the molding powder becomes partially liquid and is forced to fill the contours of the mold. It then becomes cured in that shape and can be removed hot after allowing the proper curing time.

Compression molding is usually performed with hydraulic or air presses of the manual, semi-automatic, or automatic types, with effective pressures ranging from a few tons to several hundred tons. The air presses, of course, find their chief application in the smaller capacities. The molds in manual operation are loaded with the molding compound while out of the press and then are placed in the press, which is equipped with steam or electrically heated platens, controlled to the proper temperature. The press is closed for the proper curing time; following opening, the mold is removed from the press and taken apart manually, usually with the aid of an arbor press and hand tools. Of necessity, this method is limited to the molding of relatively small parts or to the molding of large complicated pieces which could not be molded by the other processes because of the complexity of the dies required.

Semi-automatic molding is really automatic except for the loading of the molding powder and the removal of the molded parts. A single button starts the cycle, which includes the closing of the press, the gassing of the mold (momentary reopening of the mold to allow escape of moisture and gases), the timing of the cure, and the opening of the press. The molds must be so designed that ejection of the parts may be accomplished by the opening motion. The molding of all but the most complicated parts may be carried out on this type of press, which is probably the most universally used.

The automatic press carries out mechanically all of the compression molding operations including the loading of the cavities and removal of the parts. The hopper on the press is simply loaded with powder, the proper amount of powder is mechanically portioned to each cavity in the mold, the complete molding cycle is automatically controlled, and the parts are then ejected by air and a more positive mechanical action. Should a molded piece not be removed properly or some other failure occur, the press will stop automatically until a correction is made. Only relatively small or simple parts are usually molded by this method, however.

The molds for plastic molding must usually be made from case-hardened, low carbon steels or from hardened alloy steels in order to withstand the rather severe wear and abrasion in addition to chemical action. It is sometimes necessary to apply a hard chromium plate to the cavity surfaces for chemical resistance or to build up worn surfaces. Mold making requires the services of skilled die makers who are well experienced in plastics molding, hence dies are usually quite expensive. In fact, it is not at all uncommon for the dies used in a press to cost more than the press itself, so that large volume production is usually required to lower the mold cost per piece to a reasonable figure. The design of molds and auxiliary equipment is a problem requiring the application of engineering principles and skill, especially if production costs are to be kept at a minimum.

INJECTION MOLDING

Injection molding is a method usually applied to thermoplastic molding materials, although the principle has been used to advantage with thermosetting materials in raising production rates and cutting production costs. Thermoplastic materials, inci-

dentally, are compounds which soften on heating and can be remolded or reused repeatedly. These materials have, as their chief advantages, wide color range and good appearance, wide range of physical properties, and high speed with which parts may be produced, although the material costs are usually higher than those of thermosetting compounds. Many of their applications are decorative in nature, although their industrial and commercial uses are many.

The typical injection molding press consists of a hydraulically operated injection cylinder and a hydraulic clamping mechanism into which the mold is fastened. The injection cylinder is heated so that the plastic material will be softened enough for injection into the closed cool mold at pressures of 20,000 to 30,000 pounds per square inch. Pressures as high as 100,000 pounds per square inch have been used, although a recently developed press will operate at pressures as low as 1,500 pounds per square inch as a result of an ingenious plasticizing chamber separate from the injection cylinder. Because of the hydraulic action of the plastic material, the clamping pressure on the mold is seldom below 100 tons, even for the smallest capacity presses, and is more often several hundred tons. The capacity of an injection press is based on the ounces of material which can be injected with each piston stroke, the maximum at present being in the neighborhood of 32 ounces. It may be noted that the compression press will mold practically any amount provided that the projected area of the pieces will permit correct molding pressures.

The molds for an injection press are similar to the molds for compression molding except for the addition of sprue and runners for conducting the material to the cavities from the injection cylinder nozzle. There is, of course, no loading space in the injection mold, and the mold is kept cool by water circulating through channels. The material hardened in the sprue and runners, in addition to rejected parts, may be reground and remolded—an advantage not possessed by the thermosetting plastics.

The injection molding principle is also used in the transfer or plunger molding of thermosetting plastics. In transfer molding, the mold contains a transfer pot (a cylindrical cavity from which the molding compound is ejected by the transfer piston) with a sprue and runners leading to the cavities in a manner similar to injection molds. The molding compound is loaded into the transfer pot and, with the action of heat and the pressure exerted by the transfer plunger, is forced into the cavities where it is cured. The molded parts, upon removal, are attached to the runners and sprue, while a thin disc of cured material is left in the transfer pot.

In plunger molding, the upper cavity retainer plate carries the transfer pot, with the upper surface of the lower plate acting as the bottom of the pot when the mold is closed. Runners lead directly from this chamber to the cavities, with no sprue re-

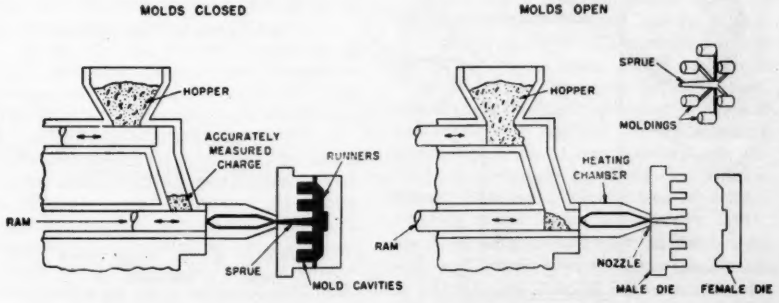

Figure 2. Injection molding.

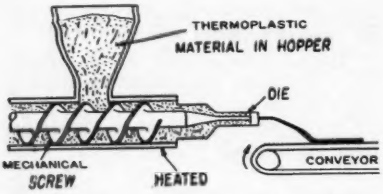

Figure 3. Extrusion molding.

quired. The molded parts upon removal are attached to the runners, which usually radiate from the thin disc of cured material from the transfer pot. Both methods speed the cure of the material, because of the quicker heating of the low-heat-conducting plastic materials.

EXTRUSION

Extrusion is used primarily for the thermoplastic materials in the fabrication of rods, tubes, and other shapes which are long in comparison with their cross-sectional area. It is also used to a great extent in the coating of wire for electrical insulation. The extrusion press consists of a heated cylinder in which is mounted a screw that, upon rotation, forces the plasticized material through an orifice or die to form the desired shape. In wire coating, the material is extruded directly over the wire which is passed through the orifice usually mounted in an L-shaped head on the press. After extrusion, the material is received on a moving belt and cooled before coiling or cutting to length. Large amounts of decorative trim, pipe and tube, and rod for machining or bending are made by extrusion.

LAMINATING

Laminating is the method used for the manufacture of sheets, rods, and tubes by using cloth, paper, asbestos, glass cloth, or wood sheets and bonding them together with thermosetting resins at pressures from 1,000 to 2,500 pounds per square inch and at 300 to 350° F. Usually, the laminating material in rolls is coated with the resin varnish and then dried to help advance the cure. The proper size sheets are then cut and stacked to give the desired thickness of the finished product. These stacks are placed in a multiple platen press, and the proper heat and pressure are applied for the required curing time to form a strong bond between the filler sheets. In making tubes and rods, the sheets are usually rolled on mandrels until the proper thickness is built up and are then placed in a heated mold, where pressure is applied until cured. If rods are being made, small mandrels are used and removed before placing the material in the mold. Some tubing is made by simply rolling on a mandrel and then curing for long periods of time without pressure.

Low pressure laminating is basically the

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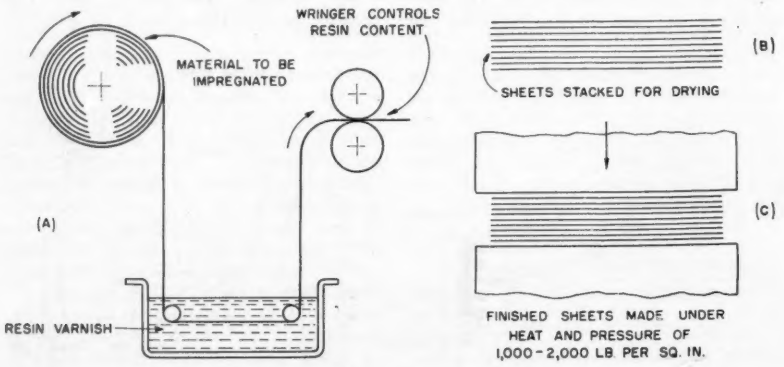


Figure 4. Laminating.

GEORGIA AND THE PLASTICS INDUSTRY

By JOSEPH B. HOSMER*

The preceding articles in this issue have dealt with the materials and fabrication processes which constitute the technical background of the plastics industry. To interpret these facts in the light of the Georgia scene, however, requires careful analysis, and this is the purpose of the article which follows.

As has been mentioned in the other articles of this symposium, the "business" of the plastics industry may be divided for analysis into two distinct phases: (1) production of chemical raw materials, intermediates, and the plastics themselves, and (2) production of finished articles from the plastics. In between these categories are the production of plywood, which must usually be handled further (furniture manufacture, etc.), and the production of adhesives, paints, etc., but for the purposes of analysis of the plastics industry these may be considered as finished products.

The two big Georgia opportunities in the plastics field appear to be the production of plywood and the manufacture from plastic materials of decorative trim and parts for automobiles, both of these opportunities being in the application field and not in the production of raw materials. Plywood for furniture is already being manufactured here by nine plants, and the new Ford and General Motors automobile plants, when in operation, will provide a market of considerable size for trim and plastic parts which ultimately will have to be supplied either by local manufacturers or by branch plants of the larger national plastics molders.

As regards the further production of plastic materials from basic Georgia resources, near-future developments will probably be chiefly concerned with naval stores and cellulose from wood pulp.

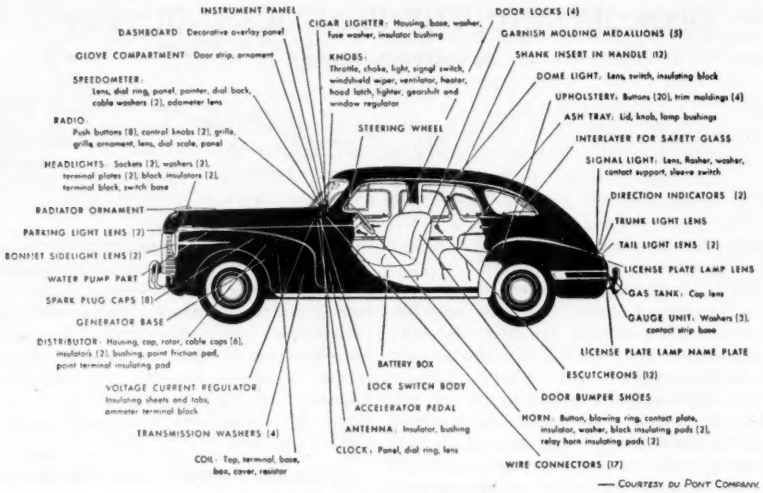
As regards the national scene, the largest concentration of plants manufacturing plastic materials occurs in New Jersey which, with the addition of plants in New York, Pennsylvania, Connecticut, Massachusetts, Illinois, and Michigan, accounts for most of the current total of more than 1,000,000,000 pounds per year, a production having a value of more than $300,000,000. Fabricators utilizing these raw materials, however, are more widely distributed over the United States, although most of the processing plants are in the same areas as plants producing plastic materials; in addition, however, both the Southeast and the Pacific Coast have numerous processors, mostly making plywood.

GEORGIA PLASTICS PROCESSING PLANTS

In the processing field, in addition to the nine Georgia plywood plants, a subsidiary of Chicopee Mills is producing a variety of woven plastic products at Cornelia and Buford. These fabrics are being used for window screen, automobile upholstery, draperies, etc.; industrial uses include "filter cloth in a cider press, reinforcing for the felt belt of a paper machine and for the paper liners of shipping containers, drying trays and bags in the cheese industry, storage battery separators, coverings for blowers in corrosive atmospheres, and a conveyor belt in a phosphoric acid plant."[2]

The Cornelia plant, the largest weaver of fabrics from Saran plastics, "got its start in the business in 1940. Throughout the war all monofilament Saran cloth, of which Chicopee supplied by far the largest portion, was drafted for insect screening in tropical areas, where it outlived bronze screening several times over. Come reconversions, the company switched to domestic window screens, launched a colorful line of decorative fabrics, and finally in November, 1945, began pushing industrial applications. Its mill at Cornelia, Georgia, completed early in 1946, is the first in the country to be designed and built exclusively for weaving plastics. Except for experimental runs with

*Fellow in Industrial Economics, State Engineering Experiment Station.


INSTRUMENT PANEL
DASHBOARD: Decorative overlay panel
GLOVE COMPARTMENT: Door strip, ornament
SPEEDOMETER: Lens, dial ring, panel, pointer, dial back, cable washers (2), odometer lens
RADIO: Push buttons (8), control knobs (2), grille, grille ornament, lens, dial scale, panel
HEADLIGHTS: Sockets (2), washers (2), terminal plates (2), block insulators (2), terminal block, switch base
RADIATOR ORNAMENT
PARKING LIGHT LENS (2)
BONNET SIDELIGHT LENS (2)
WATER PUMP PART
SPARK PLUG CAPS (8)
GENERATOR BASE
DISTRIBUTOR: Housing, cap, rotor, cable caps (6), insulators (2), bushing, point friction pad, point terminal insulating pad
VOLTAGE CURRENT REGULATOR: Insulating sheets and tabs, ammeter terminal block
TRANSMISSION WASHERS (4)
COIL: Top, terminal, base, box, cover, resistor
CIGAR LIGHTER: Housing, base, washer, fuse washer, insulator bushing
KNOBS: Throttle, choke, light, signal switch, windshield wiper, ventilator, heater, hood latch, lighter, gearshift and window regulator
STEERING WHEEL
BATTERY BOX
LOCK SWITCH BODY
ACCELERATOR PEDAL
ANTENNA: Insulator, bushing
CLOCK: Panel, dial ring, lens
DOOR LOCKS (4)
GARNISH MOLDING MEDALLIONS (5)
SHANK INSERT IN HANDLE (12)
DOME LIGHT: Lens, switch, insulating block
UPHOLSTERY: Buttons (20), trim moldings (4)
ASH TRAY: Lid, knob, lamp bushings
INTERLAYER FOR SAFETY GLASS
SIGNAL LIGHT: Lens, flasher, washer, contact support, sleeve switch
DIRECTION INDICATORS (2)
TRUNK LIGHT LENS
TAIL LIGHT LENS (2)
LICENSE PLATE LAMP LENS
GAS TANK: Cap lens
GAUGE UNIT: Washers (3), contact strip base
LICENSE PLATE LAMP NAME PLATE
ESCUTCHEONS (12)
DOOR BUMPER SHOES
HORN: Button, blowing ring, contact plate, insulator, washer, block insulating pads (2), relay horn insulating pads (2)
WIRE CONNECTORS (17)

— Courtesy du Pont Company

Figure 1. Plastics in the prewar car.

other plastics, the mill is devoted entirely to weaving a variety of monofilament Saran fabrics, all of which are marketed under the name 'Lumite'."[2]

The Scripto Manufacturing Company is another large Georgia firm which employs plastics processing, in this case for the production of mechanical pencil barrels. This firm's use of plastics began during the war and apparently has increased considerably in volume in the past year.

There are two custom molding firms in Atlanta, the Atlanta Plastic Products Company (a view in whose plant is shown on the cover of this issue), and the Southern Plastic Industries, Inc., and one firm, Beeline Plastic Company, which machines and finishes plastic rods and blanks.

GEORGIA OPPORTUNITIES

The existing plywood industry in Georgia and the Southeast is almost entirely devoted to producing hardwood plywood for furniture and other uses, while on the Pacific Coast the plywood is largely produced from Douglas fir for construction use. There are indications, incidentally, that Pacific Coast plywood operations may be near their potential capacity, so that, in the event that a satisfactory construction type can be produced from Southern pines, there is an obviously large market awaiting development. The problem posed here is being made the subject of a detailed economic analysis by the Industrial Economic Research Staff of the Georgia Tech Engineering Experiment Station, which analysis will be published later. Only the general facts need be discussed here, therefore.

The points which make it appear reasonable that a pine plywood industry may be developed in Georgia and the Southeast are:

1. The excess of annual forest growth over present use is larger in the Southeast than elsewhere.[3]

2. Georgia's strategic position with respect to both Southern and Eastern construction markets.

3. The generally increasing demand for construction plywood.

In regard to automobile uses, both the Ford and General Motors automobile plants near Atlanta should be in operation this year. The automotive industry is the third largest industrial user of plastics, being exceeded only by two divisions of the electrical

Continued on Page 20

DEVELOPMENT OF SEED-PLANTING MACHINERY

By R. A. HALL*

Realizing that, despite current extensive industrialization, agriculture is still the major vocation of the South, the State Engineering Experiment Station has long given careful attention to the design and improvement of various types of agricultural machinery. One illustration of this work is contained in the following account of the development of a high-speed seed planter, designed primarily for tractor mounting and capable of operating at more than twice the speed of conventional horse-drawn equipment.

Agriculture is an industry which is closely allied to and highly dependent upon the basic sciences of biology, chemistry, geology, *and* the engineering sciences. Knowledge of the composition and the chemical and physical demands of plant life is not, in itself, sufficient for the proper production of large food crops. Especially when agriculture is carried out on a large scale, it is essential that equipment be used which has been designed and built in accordance with scientific principles, so that the food crop produced through use of this equipment may be of the highest quality and quantity.

The mechanization of agricultural operations is a step toward emancipation of the farmer from some of the remaining vestiges of primitive, back-breaking toil. Further, when properly applied, it makes possible the proper spacing of plants, high-speed planting at the right time (which may be very short), rapid and efficient harvesting, and the processing (where such operations are required) of higher quality produce.

No agricultural industry offers better prospects for gain from mechanization than does the peanut industry, and this fact is well realized by it, as witnessed by the emphasis being placed on research by the National Peanut Council. In the summer of 1945, therefore, when this organization made available a sum of money to the Georgia Agricultural Experiment Station for research on peanut problems, the latter group decided that these funds should be utilized for the development of an improved type of peanut planter and, in accordance with its policy in matters of engineering design, asked the State Engineering Experiment Station to undertake jointly with it the design and testing of a model planter.

*Research Engineer, State Engineering Experiment Station.

PEANUT PLANTING

Both stations are vitally interested in matters concerning peanut growing, for the peanut is today the basis of a major industry in Georgia. The state's large contribution to the national production has gained more significance since peanut butter, salted peanuts, and peanut candy have become staple items in the American diet; peanut oil has become of increasing importance for cooking, in margarine, and in salad oils; and peanut flour and meal for stockfeed have become important by-products. Georgia has ranked first in peanut production since 1929 and, in recent years, has produced about one-third of the United States crop. Of the 2,079,600,000 pounds of nuts harvested in 1945, Georgia contributed 704,700,000 pounds,[1] a fact which well explains the increasing interest in peanut production, processing, and consumption.

Fundamental to the progress of this industry as a whole are improvements in the actual agricultural methods employed in the planting of the peanut seed. In connection with this problem, the Georgia Agricultural Experiment Station had previously conducted research on certain phases of the subject and had released some important data on experiments concerned with the optimum spacing of peanut seeds for good crop yields. This research showed that seeds of the Spanish peanut, when spaced approximately three inches apart in rows separated by 24 to 30 inches, gave a typical yield of 1,550 pounds per acre, whereas a six-inch spacing

yielded only 1,250 pounds per acre and a twelve-inch spacing gave only 990 pounds. For the runner type of plant, the optimum spacing was found to be about six inches in rows placed 30 inches apart.[2]

Standard planting equipment is now available which will theoretically plant peanut seeds at spacings as close as 1½ inches. However, at the high planting speeds commonly used in large fields during the rush to plant at the right time, these close spacings cannot be realized. Either the planting plates of the standard peanut planters rotate too fast to pick up the seeds effectively, or the seeds, in dropping through the planting tubes, begin to spiral instead of falling freely, resulting in irregular bunching of the seeds on the ground instead of regular spacing. The desired and important uniformity of close spacing is thus lost, and a decrease in yield is the inevitable result.

It should be noted that the problem encountered here—the planting of seeds spaced, for example, 2½ inches apart by a machine moving, say, six miles per hour—is by no means a simple one. Under these conditions, the planter must accurately deposit about 42 seeds per second, one at a time and without damage to the seeds.

DEVELOPMENT PROGRAM

In order to plan the research on the new seed planter properly, a conference was held between Mr. J. G. Futral of the Georgia Agricultural Experiment Station, Professor Robert L. Allen of the Georgia Tech Mechanical Engineering Department, and other

Continued on Page 22

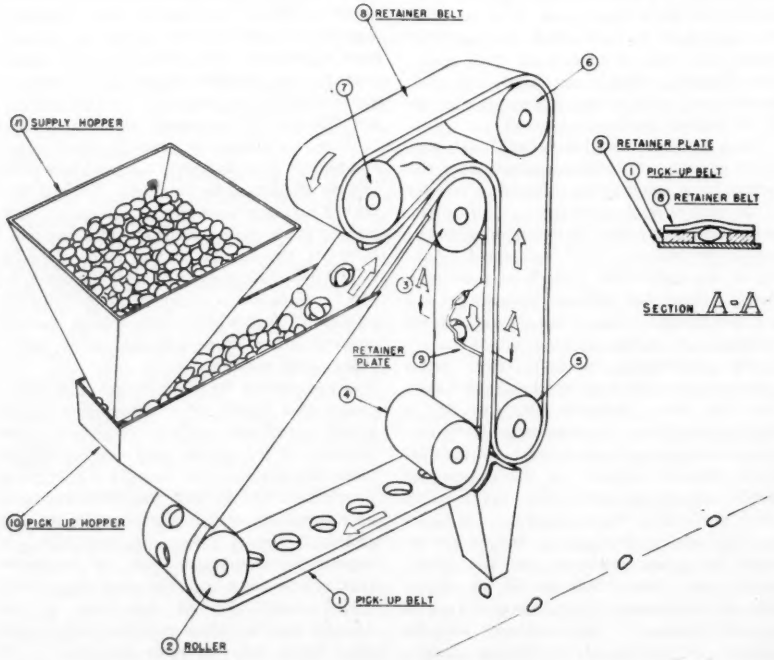


Figure 1. Operating principle of seed planter.

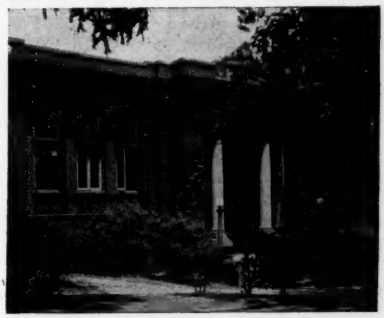
REPORT FROM THE LIBRARY

By DOROTHY M. CROSLAND*

In the last issue of this journal I related some of my experiences while searching for books and periodicals in England and Scotland last fall. I shall now describe my journey to the European continent—to Stockholm, Copenhagen, Amsterdam, The Hague, Brussels, Paris, Zurich, Basel, and then back to America via London. Thanks to air travel, I covered some 13,000 miles in ten weeks. Peoples in all these foreign lands have become my friends and friends of Georgia Tech.

I was scheduled to fly from London to Stockholm on October 29, but because of fog and low ceilings the plane was grounded at Goteborg, and the journey had to be continued across Sweden by rail. Such beautiful country—I shall always remember my rides to Stockholm and later down to Malmo. Stockholm, one of the world's great capitals, is a lovely city which is remarkably clean and has beautiful buildings and sculpture everywhere. As regards library material, imagine my surprise when, in the basement of G. Ronnell, Antikvarisk Bokhandel, I found a long file of the *Papers of the Technical Association of the Pulp and Paper Industry*, American volumes that we had been trying unsuccessfully to buy for years. It was almost like finding friends to see these familiar books, and I am happy to report that these volumes have already been received by our library and that our file is now complete with the exception of four numbers. Moreover, I found other desired journals in this same book store, and these too have arrived and are waiting to be unpacked.

I also visited Mr. Bjorkbom, the librarian of Kungl. Tekniska Hogskoland Bibliothek (Royal Technical University Library), who was most helpful and kind. His library building is new and contains an outstanding collection of books and journals on science and technology. Exchange relations between our two libraries were established. I had time for visits to the Public



Library, the Royal Library, and other book stores; my contacts in Sweden were fruitful indeed.

From Stockholm, I journeyed by rail to Malmo and was ferried across to Copenhagen. I left a country that had not been in a war for over 130 years, where one could buy many articles still missing in America, where there seemed to be plenty of everything, including food. In Denmark, however, the stamp of the German occupation was visible everywhere. I found Copenhagen grey and dismal. It was cold, but all use of hot water was forbidden. One feels so sorry for the peoples of those countries that were occupied by the Germans.

The book stores in Copenhagen yielded little to my collection of purchases. Several times, after thinking I had found a valuable collection which would be available for purchase, I learned that it was not for sale. I visited Danmarks Tekniske Hojskole Bibliotek and, in the absence of the librarian, Mr. Juul very graciously took me over the library building, which is new. I continued to find in these libraries, just as I had in England, books and journals that we need in our Tech library but that I could not locate through book dealers.

From Copenhagen, I flew to Amsterdam, where I spent a day at Swets and Zeitlinger's office. It was nice to visit a firm from which we had made purchases several years before

*Librarian, Georgia School of Technology.

the war. Mr. N. V. Swets was hospitable and did all that he could to help us. He has a large stock of journals, but unfortunately his files are very broken. One hesitates to buy when the run is so incomplete. I did purchase some periodicals, however, and two cases have already arrived.

Leaving Amsterdam, I travelled on to The Hague, where I found that Mr. Wouter Nijhoff of the Martinus Nijhoff Company had several sets of periodicals that I wanted. These were purchased and have already arrived. One of the journals that I purchased there was the *Annalen der Physik*, second series. Both Mr. and Mrs. Nijhoff were most kind, taking me to the Royal Library, the American library, and Delf. My visit to Holland was pleasant, but I shall never forget the scenes of destruction wrought by the Germans.

Brussels, my next stop, did not have any book dealers who seemed to have items on my desiderata. I went to the University of Brussels, however, and spent several hours in the library where I established exchange relations; we are to receive *Revue de L'Ecole Polytechnique*.

I arrived in Paris on November 15. It was raining, and it continued to rain 13 out of the 15 days that I was there. I was not too successful in finding many of my "wants" at book dealers, but I did find that the publishers could supply complete files. It took much time to look up addresses and make contacts; nevertheless, I was fortunate in adding many volumes to my collection in Paris.

Mr. Otto Hafner of the Stechert-Hafner Company gave me every assistance, and Mr. Freyman of Hermann et Cie most graciously took me to meet M. Germain Calmette, librarian of the Sorbonne, and to visit some chemistry laboratories. I also visited the Bibliotheque Nationale, which is quite wonderful; the Institut de France; the Mazarine Library; the American Library; and the United States Information Service Library. The last two libraries, incidentally, can not

Route of Mrs. Crosland's trip to Europe in search of library materials.

meet the demands for American scientific and technical books. My trip to Paris was worthwhile, and, could I have remained longer, I know that I would have found more items that I wanted.

On November 30 I flew to Zurich. The Technische Hochschule there is one of the world's outstanding engineering institutions. I spent two days in its library, which has one of the finest engineering collections that I have ever seen. The bibliographic division under Mr. Mikulaschek contributes much to research in Switzerland, and it is truly a library for the research worker. Both Dr. Bourgeois, the National Librarian who was formerly Technische Hochschule librarian, and Mr. Mikulaschek were so kind as to give me assistance. We shall receive some 1,400 doctors' dissertations from this university. I shall always remember my visit to the Eidg. Technische Hochschule Bibliothek.

I spent one day in Basel at Wepf and Company, where I found more journals to add to my already large collection of purchases. Altogether, I spent five crowded days in Switzerland.

December 5 found me on my way back to New York, by way of London. Because of weather conditions, however, the plane was delayed, and I had four days to spend in London. I made more calls on publishers and found a few more volumes to send to Georgia Tech. I can not leave the mention of London without a word of thanks for Miss A. L. Baker of the Stechert-Hafner Company, who arranged to pack and ship many of the volumes that I had acquired on my journey through England. These boxes have come, and the periodicals have already been unpacked.

On December 9, a grey, gloomy day, I left London for New York. The trip across the Atlantic was miserable. For most of the eleven hours from Shannon to Gander, Newfoundland, we flew just above the ocean, with the cabin lights on "Fasten seat belts." I, along with most of the other passengers, definitely was air-sick. We were due in New York at 6:30 A.M. on December 10, but again the elements played their part well—we could not land, so had to go back to Hartford, Connecticut, where we landed about 10:00 A.M. How good it was to be back on American soil!

My long trek was over. It had been successful in many ways. I did find many books and journals to purchase, and I had many volumes given to our library. I made many good friends, and now many more people know that we have an engineering institution in the South.

In the next issue of THE RESEARCH ENGINEER, Mrs. Crosland will list some of her important acquisitions.

PLASTIC MATERIALS

Continued from Page 6

plastics are available only in the form of sheets, rods, and tubes which must be cut or machined into finished forms because the plastic is not readily molded. Common uses include buttons and novelty jewelry; adhesives and paper coatings are also produced. The *coumarone-indene resins*, obtained from the light oil produced in the coking of coal, are either semi-fluid, viscous materials or hard, brittle plastics; uses include mastic floor tile, chewing gum, transcription records, electrical coils, and ceramic binders. *Shellac* and *bituminous plastics* were among the earliest commercial types; the latter are used almost exclusively in battery boxes, while the former are used as binders for phonograph record compositions, abrasives, etc.

The *silicone resins*, introduced during the war, are of great importance in the field of electrical insulation. The *allyl resins* show unusual promise as transparent thermosetting materials. Other new plastics include polyvinyl carbazole, polydichlorostyrene, and tetrafluorethylene polymers. Countless other plastics are in the developmental or introductory stages.

Agricultural Plastics

Many of the plastics mentioned so far use intermediates (alcohol, methanol, acetic acid, etc.) which are derived in part from agricultural materials, but there is also a growing list of plastics based directly upon these latter substances. *Soybean plastics*, de-

rived from soybean protein which has been hardened by formaldehyde, have been given considerable publicity but have not yet found much application, because of serious limitations (inferior strength, lack of water resistance, length of curing time).

Lignin plastics, chemically lignocellulose plastics, are potentially available in vast quantities from the waste sulfite liquors produced in paper manufacture and from a variety of products including sawdust, wood chips, sugar cane (bagasse), corn stalks, and other waste farm residues. Lignin materials may be pressed into rods, sheets, and tubes, or may be mixed with phenolic or other thermosetting resins to form compression-molding compounds, impregnating varnishes, and adhesives. Products include switchboards, signs, door kicks, cabinets, and foundry pattern plates. Masonite board, for example, is well known. The ready availability of raw materials at low cost justifies considerable research attempts to expand the usage of the lignin plastics.

Zein is a protein developed from corn gluten and used as an ingredient in paper coatings, as a substitute for shellac, etc. *Vinsol resins* are extenders and modifiers produced from naval stores and used as a shellac substitute, as an emulsifier for asphalt, as a conditioning agent for Portland cement, and as a treating agent for laminated paper. *Polyterpene resins*, catalytically polymerized from turpentine, are useful in coatings, adhesives, and chewing gum. *Caffelite plastics*, made from coffee, were announced several years ago by the Brazilian government but have not yet appeared commercially. *Casein plastics* have been previously mentioned.

AUXILIARY MATERIALS

As has been noted, the manufacture of plastic articles requires plastic materials which contain huge quantities of fillers, coloring materials, plasticizers, and solvents in addition to the plastics themselves. *Fillers* serve a variety of purposes—to improve strength, impact resistance, etc.; typical examples are wood flour, cotton, chopped or shredded cloth, paper pulp, graphite, and asbestos.

Plasticizers are usually nonvolatile liquids added to plastic compounds to toughen them or make them softer, as the case may be. Phthalates and phosphates are the chief plasticizers used. *Solvents* are vital to the plastics industry for use in the preparation of lacquers and adhesives and in actual manufacture and fabrication; many different ones are employed.

SELECTION FOR USE

It is certainly evident, by now, that there are many different plastics available for use and that more are being developed to serve new purposes or to replace scarce or more expensive materials.

The would-be user of plastics, therefore, must compare the properties of the available plastics to determine those which will best suit his purpose, consider their comparative costs, inquire carefully into the details of mold design, decide upon type and capacity of press, and go into production only when consideration of all these factors results in the conviction that the article will meet the required specifications both as to quality and price. Some of these factors need not be determined by the user alone, of course, if a custom molder is to be employed, but these must then be considered by the latter.

RESEARCH OPPORTUNITIES

It goes almost without saying that the opportunities for research in the plastic materials field are practically without limit. New materials must be sought to meet specific needs; drawbacks in existing plastics must be overcome, either by modification of polymerization, addition of new reactants, or by use of compounding ingredients; plastics uses must be sought for materials which are abundant and inexpensive but little used.

Such research is a nation-wide problem, for plastics are widely used materials, but it is also of importance to those regions which possess substantial supplies of raw materials or have need of plastics for specific uses.

Plastics, in reality, differ little from such other materials of commerce as metals and ceramics; they have properties dependent upon their types and specific compositions and should be selected in accordance with engineering specifications. The multiplicity of available types and the variation in prop-

erties of a given type from one manufacturer to another are causes for close attention, but this is but another phase in the task of materials selection.

In any case, the present intense demand for plastics—far in excess of available fabrication capacity or material supplies—bears witness to the statement that plastics are not "war babies"; that wartime expansions were far from mushroom growths. There is every reason to believe, therefore, that industry in general will continue to require more and different plastics in its operations.

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THE FABRICATION OF PLASTICS

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same, except that resins are used which will cure without the application of pressure or with the use of only very low pressures, such as that up to 100 pounds per square inch. For these low pressures, rubber bags to distribute fluid pressure are frequently used. Other means used include sand bags, hydraulic jacks, carpenter clamps, springs, and such hydraulic presses as are used in the manufacture of plywood. This method is the one used in the manufacture of large structural shapes, as for example, the plywood aircraft developed during the war.

OTHER METHODS

Casting has long been used to a limited extent with certain thermosetting materials and a few thermoplastics. The liquid resin is poured into mold forms and cured. This method is advantageous for use in the preparation of large, simple objects, but cast parts need more finishing, and the process is quite slow.

For the manufacture of papier-mache and similar materials, *pulp molding* is employed. A mixture of pulp and resins, suspended in water, is deposited upon a porous form having the shape of the desired article, the water being drawn off by a vacuum. When the desired thickness is obtained, the article is dried and molded under slight pressure into final form and finish.

Blowing comprises use of air or steam pressure in closed molds to form articles from thermoplastic sheets or extruded charges. *Drawing* is used to stretch sheets of plastic materials over a form in order to obtain the desired shape; sheets may also be drawn through a die by means of a shaped plunger.

FINISHING

After the basic process of fabricating, there frequently remains considerable finishing and assembly to be done before the part may be sold. The operations may include deflashing of compression molded parts, degating injection molded parts, tumbling, polishing, and buffing. For assembly operations, the parts may also require drilling, tapping, machining, lettering, and other mechanical operations similar to those used with other structural materials.

The choice of the material to be used and the method by which a part is to be fabricated depend on the subsequent use of the plastic part. A consideration of many properties should usually be made—the physical, chemical, and electrical properties; color; appearance; weight; etc. For more detailed information, the reader may refer to any number of books, periodicals, and other publications devoted exclusively to the plastics industry.

Proper fabrication of plastics is essential to the production of satisfactory articles in an economic manner. Present methods and equipment have their limitations, and much engineering research is continuously needed to remove "bugs," lessen costs, and improve versatility. Nevertheless, recent years bear testimony to the increased utility of plastic articles and serve to forecast greatly increased future application.

GEORGIA AND THE PLASTICS INDUSTRY

Continued from Page 12

industry, radio and household appliances. The prewar automobile used plastics in about 100 different parts, to the extent of between 3.7 and 7 pounds of plastics per automobile. Since the Atlanta assembly operations of major motor car manufacturers may be expected to reach a total of above 200,000 vehicles a year, an extrapolation of these figures would represent a market for 740,000-1,400,000 pounds of plastics, a very considerable part of which could probably be processed more economically in Georgia than elsewhere, if for no other reason than that it is often cheaper to ship in raw materials instead of finished products.

Another "plastics" processing opportunity to be found in Georgia is in the impregnation of soft woods with urea-formaldehyde resins, a process which produces a dense and strong material which may be used either structurally in furniture or for machined parts such as gears, rollers, etc. Engineering and production research on such products was conducted at the Georgia Tech Engineering Experiment Station in 1945.

There are many plastics uses for which the processing could as logically be done in Georgia as elsewhere, ranging from the manufacture of dolls, toys, advertising gifts, and other novelty items on the one hand to utility items such as household utensils on the other. The success of such manufacture, however, will depend, not primarily on the suitability of Georgia for plastics manufacture, but rather on the managerial skill of the investing groups, the soundness of their market analyses, and the quality of the sales efforts employed.

The present large-scale use of alkyd and related resins is of particular interest to Georgia. In 1945, for example, 33,429,000 pounds of the alkyd resins were of the class which is "modified by rosin esters," and 65,977,000 pounds of "unmodified rosin esters" (reaction products of purified rosin with glycerine and other polyhydric alcohols) were also produced. The alkyd and related resins are important ingredients in many paints and varnishes; they also find use in lacquers, printing inks, and similar products.

The importance of plastics markets to rosin sales may be judged by the fact that 1945 production of rosin totaled about 700,000,000 pounds which sold at a unit price of about 6.76 cents. It may be noted, therefore, that use in plastics probably accounted for about 10 per cent of sales, a factor important in itself but also indicative of future potentialities.

The modified alkyd resins sold for 21 cents per pound and the unmodified rosin esters averaged 12 cents per pound; profitable margins are therefore indicated. Paints and varnishes are consumed in large quantities in the Southeast; more plants to produce both resins and paints from Georgia rosin might therefore be economic.

In addition, further research may intensify the utility of such naval stores derivatives as the Vinsol and polyterpene resins and may add other resins to this list.

PROBLEMS OF NEW MANUFACTURERS

The Southeast is in a much better position with respect to fundamental "know-how" for the plywood segment of the plastics industry than for molding operations, for most of its present operations are in the former field. Furthermore, it must be pointed out that any firm entering the molding field will be confronted with both technical and economic problems, on the one hand, and an alert competition on the other. This caution must not, of course, be taken to mean that these problems are insurmountable, but simply that they must be faced realistically.

The advantage of lower weight possessed by many of the plastics is often balanced by a higer cost per pound when comparison is made with metals. In consequence, the plastics fabrication industry must often depend on the mass production economics inherent in large orders, where expensive gang dies

and other special mechanical accessories can be quickly charged off and where intensive planning can be used to reduce costs. Inspection systems and material controls must be of a high order, and sound cost accounting is the key to both sales and profit.

These requirements mean that the engineering services available within a new plastics organization must be of superior quality and that product design (both on contract work and production for sale) must be reviewed both from a functional use viewpoint and with the objectives of simplifying processing and insuring quality.

Production engineers, chemical engineers, and management executives with experience in the plastics field are naturally already employed by those firms who have pioneered in plastics processing in the New York-New Jersey-Pennsylvania area, in New England, in the Middle West, and elsewhere. Consequently, it will be difficult to secure equally capable men for new firms. Some men not yet at the top of established firms can probably be secured—often on the basis of an interest in the company, but care should be exercised by industrialists, when selecting such men, to insure that their willingness to consider the offer stems from both ambition and ability, rather than from the dissatisfaction of mediocrity. If the major executive position can be well filled from this source, then the balance of technical staff requirements can probably be capably filled by recent graduates from such colleges as Georgia Tech and other Southern technical schools.

The other alternative, of course, is for these Southeastern markets to be supplied by the already existing processors, either by shipping from present plants or by the erection of branch plants staffed with assigned personnel. Such methods would, of course, supply Southeastern manufacturers with the required plastic materials, but they would not add as significantly to the industrial development of the region.

In the processing field, the capital requirements vary in general with the size of objects for which the plant is tooled and the total number of pieces to be produced. Where the market for a specific item is assured and continuous, an operation of "shoestring" proportions can generally be figured out, but in general the capital structure should be ample and should contain some provision for those mistakes or initial inefficiencies which are inherent in a relatively new and expanding industry. To attain an annual dollar in sales will apparently require, on the average, about 75 or 80 cents in capital. The capital requirements for fixed assets (land, buildings, equipment) will be somewhat less than the working capital.

These comments are presented, not in any spirit of pessimism, but merely to indicate that while plastics fabrication opportunities definitely exist in Georgia, each individual situation must be considered on its own merits, and all factors—technical, financial, market, employee training, and the economics of the industry—must be carefully examined and weighed, so that the final decision to go ahead or not will be based on a final summary which is completely separated from any mere enthusiasm for a "new industry."

MARKETS

Approached in the way suggested, plastics processing may be one of the industries by which the South can increase its basic contribution to the national economy. Entry into the business of processing plastics, however, without such a complete analysis, may lead to heavy losses if any considerable investment is involved. Many plastic products are likely to be in the nature of net additions to the national economy, rather than "substitutes" for some other materials.

This means that the justification for marketing a plastic item must be found in an affirmative answer to most of these questions:

1. Will the item perform its function better when made from plastics than from other materials?

2. Will the cost be lower, or if greater, will the increment be justified by better functional performance?

3. Will a reduction in weight, if involved, produce either a lower unit cost or increase the functional efficiency?

4. Will the use of plastics enhance the aesthetic value of the design?

The marketing of plastic products, even more than is usually the case for other items, is dependent upon a competent analysis of end uses and relative demands. This implies that such an analysis should be closely related to both product design research and cost analysis, in order that uneconomic products may be avoided. Apparently, this relationship applies both to production under contract, where the final marketing is done by others, and to operations in which the processor also distributes through wholesale or retail channels.

In the latter case, distribution planning must be unusually thorough. The probable extent of the market should be determined by market studies, and the merchandising plan should be developed in detail in cooperation with a competent advertising agency.

RESEARCH

The plastics industry is essentially a product of technical research in both the material production and processing divisions. In consequence, its economic future may be expected to reflect the continued research which is being carried on not only by the chemical firms who have originated the materials now being used and are developing new materials to meet specific use requirements, and by the large processors who are seeking more efficient production methods, but also by other scientists working in fundamental fields.

The general character of plastics research problems may be divided into several classes: (1) the development of new materials, (2) the improvement of existing materials, (3) the simplification of processing techniques, and (4) the development of new techniques. Under the first and second groups, the studies of the most interest to Georgia would naturally relate to cellulose plastics and the utilization of naval stores.

One report[1] issued in 1938 by the Georgia Tech Engineering Experiment Station showed that pulp suitable for viscose rayon can be made from Georgia pine by the sulfite process. Much additional work on the possible production of plastics materials from raw materials available in Georgia could be undertaken with probable profit. Materials deserving study include wood pulp, wood wastes, turpentine, rosin, peanut meal, and furfural.

Problems in the aforementioned two classes of processing research, which include the processing of all types of materials, may also be of interest to Georgia; as a consequence, any such problem encountered in operation is a logical problem for regional study. Any new piece of equipment developed in Georgia, moreover, is not only a contribution to the industry, but also an advantage to Georgia since it is very likely to result in increased processing of plastics within the state.

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SEED PLANTER

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members of the staff of the State Engineering Experiment Station, at which time the necessary qualifications for the proposed machine were outlined. These included the following:

1. The planter must deliver seed to the ground at a uniform spacing of 2-2½ inches (approximating the optimum spacing determined by experiment) at a planting speed of not less than six miles per hour. This is approximately twice the normal speed of a horse-drawn planter.

2. It must not injure the peanut seed in any way. Although the peanut is commonly thought of as being rather durable, even a small break in its outer covering, or skin, will prevent germination.

3. It must be of simple, rugged construction, readily adaptable to standard tractor drive mechanisms.

Actual work on this project was begun at the Georgia Tech Engineering Experiment

Station during August, 1945, under the direction of Professor Allen. In order to study the various types of existing equipment, five standard makes of seed planters were first tested at various speeds and under identical conditions of soil bed.

Results of these tests revealed two inherent difficulties common to all types: (1) the rapid rotation of the planting plates which serve to pick up the seeds from the supply hopper causes an erratic action, since the seed pockets are emptied by centrifugal force before reaching the planting tubes, and (2) the seeds begin to spiral through the planting tubes instead of falling freely. This produces the irregular bunching previously described.

In order to eliminate undesirable centrifugal action, the new planter, the principle of which is shown in Figure 1, is designed around an endless leather belt which moves along the inclined bottom of a seed hopper. This hopper is kept filled to a constant level from a larger supply hopper placed above it. As designed for planting peanuts, the belt is perforated at regular intervals with holes which serve to pick up the seed and convey them up the 45 degree incline; a fabric backing on the belt keeps the seeds from scraping against the retainer plate. Each perforation is large enough to hold one peanut seed, and the thickness of the belt is just deep enough to retain this one seed, yet shallow enough to cause any additional seeds to fall out at the selected angle of inclination.

At the top of the incline, the pick-up belt passes over a roller and is overlaid by a soft unperforated endless belt. The purpose of this "retainer" belt is to enclose the individual seeds in the perforations and to transport them down to the planting tubes with-

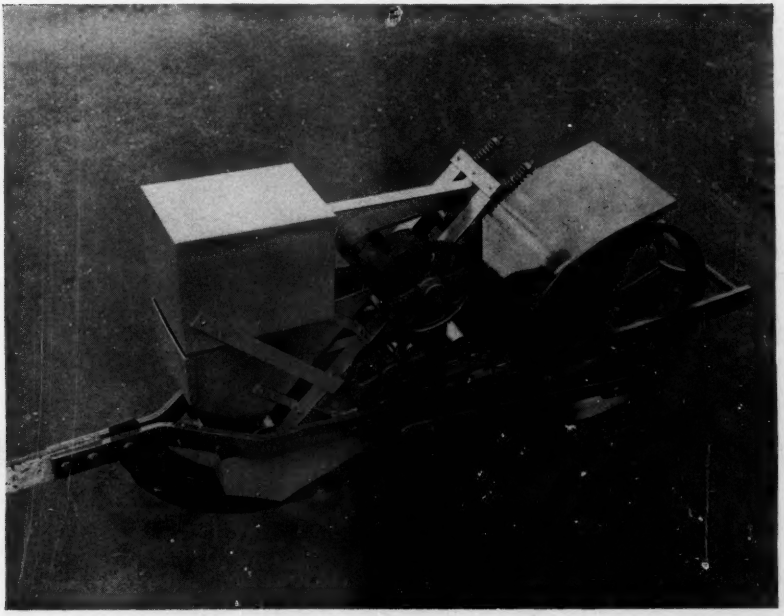

Figure 2. Experimental model of seed planter.

out injury. Release of the seeds is accomplished by separating the belts over adjacent rollers (see Figure 1) at a point close to the ground. In this manner, the distance of free fall is reduced to a minimum, and there can be no tendency of the seeds to spiral.

In the experimental machine, pictured in Figure 2, the new mechanism is mounted on a standard planter chassis which provides a soil opener blade and presser wheel. This wheel is also used to drive the pick-up belt through a connecting rod and simple gear train. The retainer belt is in turn driven by friction from the pick-up belt.

TESTING PROGRAM

During the summer of 1946, preliminary planting tests were conducted with this machine at the Georgia Agricultural Experiment Station near Griffin. Operating at speeds ranging from 2-9.3 miles per hour over various types of seed beds, a remarkably uniform spacing of approximately 2½ inches was obtained under all conditions where the soil was properly prepared; i.e., finely pulverized and freed from clods or rocks. Furthermore, the uniform stand of plants obtained showed that the planter had not damaged the peanuts and, since the plants were all single, that there had been no tendency for the planter to deposit more than one seed at a time.

In the experimental model, some trouble with "skipping" was encountered, since the planter was driven from a wheel running on the ground and clods or rocks caused this drive wheel to bounce, leaving skips in the planted seeds. This skipping will be remedied in future models by mounting the one or more mechanisms employed directly on the tractor and driving them with a conventional power take-off instead of by a ground-driven wheel. In this manner, several rows may be seeded simultaneously, thus multiplying the effective speed of the planter.

It may be noted that this experimental peanut planter contains several unique features. In order to pick up one seed at a time without injury to that seed, the perforated pickup belt of the planter is moved *upward* at such an angle that excess seeds are dislodged and fall back because of the force of gravity. Except for the previously mentioned unsatisfactory rotating disc planters, almost all similar planters studied call for the passing of the pickup belt under the hopper, following which it must pass under a retainer plate or a similar closure to remove excess seeds, a process which can easily damage these excess seeds, oversized seeds, or any seeds caught endwise in the perforations.

Another successful feature is the use of the soft retainer belt to hold the seeds in the pickup belt until the desired point is reached for dropping the seed to the ground. As mentioned, planters which throw off the seeds from an inclined rotating disc by centrifugal force, leaving them to fall freely through a chute, have little accuracy in spacing control. The seed begins its fall with no uniform imparted velocity at a necessarily long distance from the ground, a major reason for the poor control and spiraling which cause inaccurate spacing. Thus the upward motion of the belt and the use of carefully controlled delivery provide the primary requirements for a satisfactory peanut planter; that is, the ability to plant uninjured peanut seeds one at a time at regular intervals.

This mechanism can, of course, be readily adapted to the planting of seeds other than those of the peanut. Any type of conveyor belt may be used, with the belt width and the size and frequency of perforations adapted to the size of the seed being used and to the manner in which it should be planted. If two or more seeds should be deposited together, two or more perforations may be used side by side. In addition, more than one row of seeds may be planted at a time by the combination of two or more planting machines.

Further planting tests are scheduled for this spring, following which the seed planter will be ready for development on a commercial scale. Patents are pending on the unique features previously mentioned.

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